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Developing a Risk Analysis Model to Improve Study Abroad Awareness

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Developing a Risk Analysis Model to Improve Study Abroad Awareness

An undergraduate honors thesis submitted in partial
fulfillment of the requirements for the degree of
Bachelors of Science in Industrial Engineering

by

Tyler Spain

May 2016
University of Arkansas

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Abstract

As international education opportunities increase in popularity among U.S. college students (McMurtrie, 2007), it is becoming more and more necessary for study abroad organizations to be aware of the risks students face as they travel abroad. While some international cities are riskier than others, it can be difficult to distinguish between cities which truly carry a high degree of risk for visiting students, and which cities are only perceived to be risky based on various personal misconceptions. The University of Arkansas Office of Study Abroad & International Exchange currently lacks a way to quantifiably analyze the risk of study abroad programs, making it difficult to identify areas where additional student and faculty training programs are necessary to mitigate risk.

The purpose of this honors thesis is to document the process of developing a tool that takes into account multiple risk criteria in order to create a risk profile for popular study abroad destinations. By providing the user(s) of the tool with a composite risk value for each program, study abroad office staff and program coordinators will gain critical insight into the risks a student or group of students might face while traveling to particular destinations. With a better understanding of how safe each individual program is, study abroad staff members will be able to more strategically focus their educational programs and staff training, targeting particularly risky destinations in order to mitigate the potential threats associated with those programs. Furthermore, by comparing these program risk values to a familiar baseline, staff will be able to identify study abroad programs in which there is more negative perception than actual risk, which will help eliminate misconceptions of the dangers of certain global locations.

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Introduction

Study abroad programs have increased in popularity over the years (McMurtrie, 2007) (Ning & Chen, 2010) and remain a popular option for many college students seeking international exposure today. University study abroad offices across the country make it their priority to keep students safe as they travel for international education opportunities. As study abroad offices attempt to ensure safety, the key to success lies in the offices' ability to be proactive, rather than reactive, in confronting international risks. While blanket strategies (such as sponsoring non-program specific information sessions and providing students with general travel tips) can be useful for promoting general safety among all programs supported by a given department, they may also prove inefficient by either inadequately addressing the issues associated with programs of particularly high risk, or by overemphasizing issues for certain programs where the actual risk is significantly lower than the risk perceived by the department or the university's students. In order to make more efficient use of its resources and remain proactive, a university must identify specific programs in which students face a high amount of risk and distinguish them from programs in which risk is more a matter of perception than reality.

Problem Statement

Evaluating risk for study abroad programs is important to study abroad staff in universities across the country, and the University of Arkansas is no exception; however, the University of Arkansas Office of Study Abroad & International Exchange currently lacks a way to quantifiably analyze the risk of study abroad programs. To quantify the risk of individual

programs, a model must be developed to incorporate various statistics for each program in order to paint a full picture of the risks a student might face in each country of travel.

Research Questions

After a thorough review of current international exchange literature, it appears that no such model currently exists, supporting the need to build a new risk analysis model as part of this study. In this thesis, a subset of study abroad programs offered by the University of Arkansas (UA) will be used as a basis for comparison, utilizing publically available data to the university's Office of Study Abroad & International Exchange in order to compare each chosen program against each other program as well as to a baseline location. By engaging in this model development, three key research questions will be addressed:

1. What are the risk factors involved in evaluating risk for study abroad programs?
2. Are all of the risk factors equally important?
3. How should a comprehensive model be built to incorporate all risk factors?

As risk factors are identified, it will also be important to address how the factors are measured. Similarly, in the event that all of the risk factors are *not* equally important, additional consideration will be given to determining how to assess risk given these unequal weights. By answering these questions and building a risk model, this research will enable the end user to identify the composite level of risk associated with specific programs. The ultimate goal is to provide the study abroad office with a tool that will enable it to better focus its educational programs and student and faculty training initiatives in a way that maximizes risk mitigation.

Initial Scope

The first step of developing a risk analysis model is to define the scope of the study. This includes making decisions for each of the following three questions: (1) Will risk be assessed for study abroad programs only, or all international activities involving students at the organization in question? (2) Will data collection be limited to undergraduate or graduate students? (3) Will the model take into account faculty conducting research or working on development projects, or staff on recruitment or fundraising activities? (Friend, 2011). Through meetings with leaders of the UA study abroad office, who serve as the subject matter experts for this research (SME), the decision was made to limit the scope for the purpose of this model to only evaluate study abroad programs, without making a distinction between graduate and undergraduate students, and without evaluating risks associated with individual faculty travel. It was also decided not to distinguish between graduate and undergraduate students, because statistics specific to one particular group were not widely available. Also, the study abroad office staff decided they were more concerned with the risks associated with students who are travelling internationally, as most students will have little international travel experience (faculty members travelling abroad will likely have more experience and be better equipped to handle high-risk situations that might arise during travel).

Program Identification

Once these decisions were made, it was necessary to identify which specific locations the model should focus on. Several factors go into distinguishing unique study abroad opportunities; these factors include the program's destination city and country, the duration of the program, the term (intercession/spring/summer/fall/year) of the program, the presence of University faculty members, the number of credit hours offered, and the type of program being offered (direct

enrollment, exchange, etc.). When considering all combinations of these factors, the UA Office of Study Abroad & International Exchange currently offers or supports 1,385 unique study abroad opportunities for university students (HogsAbroad, 2016). Of these programs, 211 are conducted as UA faculty-led programs. These 1,385 programs serve 288 different cities within 78 countries around the world. This high volume of unique cities and countries served by the UA Office of Study Abroad & International Exchange makes it infeasible to immediately develop a risk analysis model capable of quantifying risk for every program available; for the sake of this study, a subset of ten international city and country combinations will be evaluated. Roughly half of the programs offered appear to be based in either Asia or Europe, so half of the ten chosen cities evaluated in the model will be located in one of the two regions.

To narrow down the list of destinations, 15 programs were initially selected, a subset believed to be valuable to the UA study abroad office in evaluating. The difficulty with this strategy was this: with 1,385 unique programs offered, it was nearly impossible to know with certainty which programs were actually relevant. Based on feedback from study abroad staff members, this initial list was narrowed down to four programs, based primarily on popularity. Further brainstorming with the UA study abroad office staff led to the development of a more complete list of programs that represented various concerns for international student travel. This list consisted of an additional 21 locations within 19 countries, representing other popular programs among University of Arkansas students. This list was narrowed down, and as mentioned previously, ten city/country combinations were ultimately selected by the UA study abroad office to serve as the initial test subjects for this model. The programs were selected because they each fit into one of three categories, each giving the model a sample of programs

that reflect general characteristics of a larger portion of all programs supported. The program categories and the accompanying destinations selected for this model are as follows:

- Extremely popular programs: These programs are highly popular among UA students, tend to be some of the most-traveled to destinations year after year, and include both exchange and faculty-led experiences. These programs include Dangriga, Belize; Rome, Italy; and Madrid, Spain.
- Relatively popular programs with a perception of general safety: These programs are also relatively popular among UA students, and generally are regarded as “safe” options by both students and study abroad staff. These programs include Hoa An, Vietnam; Jonkoping, Sweden; Panama City, Panama; and Sydney, Australia.
- Somewhat popular programs with a more dangerous perception: These programs are less popular than the previously mentioned programs, but are typically perceived to be relatively risky given the countries of travel. These programs include Mexico City, Mexico; Shanghai, China; and Nampula, Mozambique.

These programs represent a total of 112 (approx. 8%) of the international education programs supported by the UA Office of Study Abroad & International Exchange. This combination of programs contributes to the robustness of the model, because the three groups of programs each represent different results we would expect the model to generate (i.e., the high risk category should allow us to see that the model can identify risky programs, while the high safety category should allow the model to prove that certain programs aren’t necessarily risky). Since this model is not complete given the large volume of locations and programs served by the University of Arkansas, the decision was made to include locations on both ends of the perceived safety spectrum in attempt to incorporate variety and diversity in the types of programs and locations

evaluated by the model. It is important to understand a university's tolerance for risk in order to make policy decisions associated with international travel; to do this, it is also necessary to develop a baseline of risk which the institution is willing to accept in order to direct strategic educational initiatives (Friend, 2011). Representing risk for both of the previously mentioned categories allows the model to compute risk on both sides of the spectrum, and examining the programs against a baseline allows the user to compare the degree of safety or potential danger of particular programs (since a student would be studying at the University of Arkansas in Fayetteville if he wasn't studying abroad, Fayetteville, Arkansas was included along with the ten destinations previously mentioned to serve as a risk baseline to compare other destinations against).

It could be argued that faculty-led programs might be considered higher-risk than direct enrollment programs, as direct enrollment programs typically have a group of student services staff members available to respond to a variety of emergencies, while faculty-led programs are limited to a single or small group of staff from the home university who are less familiar with how to handle issues in the country of visit, but for the purpose of this model we will not make this distinction, as risks associated with a particular country of travel will be present regardless of the type of program a student participates in. With the study abroad office's focus on preempting risk rather than responding to problems as they occur, grouping all programs by location will help the study abroad office make decisions at the location level, thus enabling them to provide educational opportunities (when necessary) for all relevant programs.

Data Collection

After selecting the locations to evaluate in the model, we next had to determine which factors would be accounted for within each country's risk profile. Through brainstorming

sessions with the study abroad office, an initial list of 22 criteria was created to potentially assess within the model. These factors fell into four general groups; the first group included factors specific to the individual students participating in the study abroad trip being evaluated (i.e., student gender, age, prior travel experience, etc.). Another group of factors considered included information about the country itself; these criteria included crime factors (pickpocket presence, quality of police force, homicide rates, possibility of war, etc.) and health factors (food and water cleanliness, health-related deaths, access to healthcare, etc.). The third group of factors included program-specific information, such as the size of the group traveling to a particular location, the presence of University of Arkansas faculty on the trip, and the duration of the program. The remaining criteria fell into a miscellaneous bucket (i.e., vehicle accident rates, language(s) spoken, natural disaster frequency, etc.). Table 1 lists all of these initially considered factors:

Table 1 - Original List of Possible Risk Factors

Category	Criteria
Student Factors	Gender
	Age
	Previous Travel Experience
	Race
	Height
	Weight
Country Factors	Possibility of War
	Pickpocket Presence
	Public Transportation Safety
	Food/Water Cleanliness
	Quality of Police
	Language
	Crime Rates
	Access to Healthcare
Program Factors	Traveling Alone vs. With a Group
	Presence of UA Faculty
	Length of Program
Other Factors	Political Turmoil
	Natural Disaster Rates
	Road Safety
	Terroristic Activity
	Random Crimes

During the interview process, it was decided to generalize the model by location (rather than assessing risk at the individual student level) to make it more applicable on a program-by-program level, so the study abroad office could make decisions at a higher level. As a result, student-specific factors were not incorporated into the model. Because this model is designed to be used as an internal tool for the UA Office of Study Abroad & International Exchange, it was necessary to incorporate data available in the public domain so all end users would have the ability to add or modify data as necessary. When public domain data was available, it was also necessary for all data for each particular risk criteria to be available from the same source for each destination, in order to ensure consistency across all locations in the quality of data being evaluated. Because of these constraints, many of the other considered criteria were ultimately not incorporated into the model, because public domain data was not readily available from common sources. On the other hand, during the literature review process additional relevant factors presented themselves; for example, we did not initially consider a student's access to reliable internet or mobile phone coverage, but we chose to include these factors as well after finding reliable country-specific statistics for each factor and discussing the role such technological considerations might play in a student's overall safety in an unknown country.

Based on the availability of data, the following criteria were ultimately chosen for the development of the initial model:

- Communication
 - Mobile phone access (per capita) (Telephones – Mobile Cellular, 2015)
 - Internet access (percentage of population) (Internet Users, 2015)
- Health
 - Physician density (per capita) (Physicians Density, 2015)
 - Access to clean water (percentage of urban population) (Drinking Water Source, 2015)

- Access to clean water (percentage of rural population) (Drinking Water Source, 2015)
- Death Rates
 - Homicide rate (US Citizen Deaths Overseas, 2015; Crime Rate in Fayetteville, Arkansas, 2015)
 - Vehicle accident rate (US Citizen Deaths Overseas, 2015; FY2012 Performance Plan, 2011)
 - Miscellaneous accident rate (US Citizen Deaths Overseas, 2015)

Model Development – Fuzzy Logic Approach

Once data was collected for the above criteria, an algorithm needed to be implemented to compile each country's data into a single, all-inclusive "risk factor," thus allowing different destinations to be compared against each other. The issue with this was that the data wasn't all of the same type; for example, some criteria were represented by percentage values (on a scale from 0-100%), while others were represented by integer values. Also, in some cases (such as clean water access), higher values represented less risk, while in other cases (such as homicide rates), lower values represented less risk. Because the factors were represented as some combination of these two factors, all of the data needed to be converted onto the same scale to allow comparisons to be made and aggregation to be applied for the destinations' total risk factors.

To carry out these conversions, the concept of fuzzy logic was examined as a method to transform the data. Fuzzy logic is the nonlinear mapping of an input data set to a scalar output (Mendel, 1995). Converting a data set into a fuzzy logic system (FLS) requires six steps, each falling into one of three categories: *initialization*, *fuzzification*, and *inference and defuzzification*. The components of this process are briefly illustrated in Figure 1, and will be explained in the following steps (Mendel, 1995):

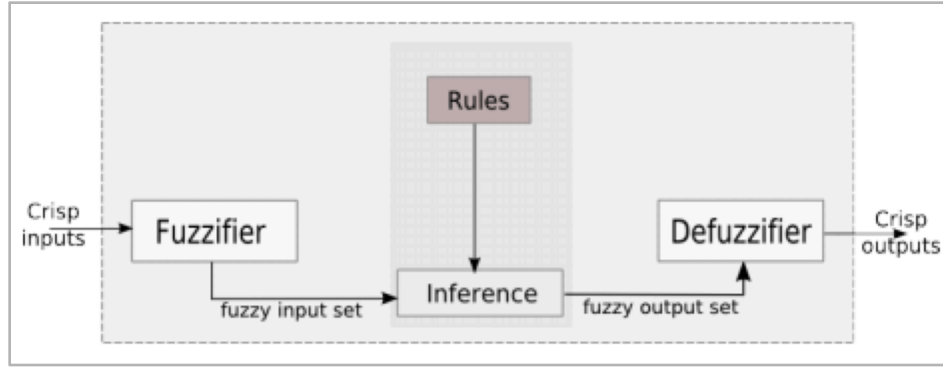


Figure 1 - Fuzzy Logic System (FLS) (Mendel, 1995)

1. Initialization

1.1. Define the linguistic variables and terms

Typically, fuzzy systems are used to represent imprecise information. In other words, when a particular data point might belong to more than one ambiguous category, fuzzy logic may be applied to convert it to a numerical quantity that makes sense compared to other values in the same family (for example, a temperature might be considered “warm,” “hot,” or both to some degree). Fuzzy logic attempts to quantify *the degree to which* a particular value belongs to a particular family (i.e., how much more does a particular temperature belong to the “warm” family than the “hot” family?).

To do this, a group of linguistic variables must be created for the data set. Many times, a data set will have multiple linguistic variables (for the temperature class mentioned above, these variables might include “warm,” “hot,” “cool,” and “cold,” for example). For the sake of this model, the study abroad office was only concerned with how risky a particular destination is for each different criteria. To account for this, only two linguistic variables were required: “Absolute Presence of Risk” and “Absolute Absence of Risk,” where each country is quantified for each criteria *to the degree to which* it represents risk to a student (Kandasamy, Smarandache, & Ilanthenral, 2007).

1.2. Construct the membership functions

Once a set of linguistic variables is selected, a series of membership functions must be derived to quantify each data point on the same scale. For a fuzzy set, outputs of a membership function take values on the interval $[0, 1]$ (Sanghi, 2005). This interval range represents the degree of membership to which each destination belongs to the presence/absence of risk linguistic variables specified in the previous step. A fuzzy set A is defined by the following expression (Sanghi, 2005):

$$A = \{(x, \mu_A(x)) \mid x \in A, \mu_A(x) \in [0, 1]\}$$

In the above function, the expression $\mu_A(x)$ represents the membership function as it converts each data point (x) to a value on the range $[0, 1]$. This concept is well illustrated by Sanghi: “Membership functions can be defined as the degree of the truthfulness of a proposition. For example, the predicate “John (X) is tall (A)” is represented by number in unit interval $\mu_A(x)$. $\mu_A(x) = 0.7$ means that John is tall to the degree 0.7”.

Several types of membership functions exist, the most common including the triangular function, the trapezoidal function, the Gaussian function, bell-shaped functions, and sigmoidal functions (Yen & Langari, 1998). The issue with all of these functions is that their peaks occur at a fuzzy value of 1, while both extremes are represented as 0's. Because only two linguistic variables were used for this model, these functions would not accurately represent extreme data values for each criteria, instead classifying data points on both extremes (minimum and maximum points) as a value of 0 (indicating the absolute absence of risk). To account for this, a less common membership function, the L-function, was selected instead. The L-function is a special

case of the trapezoidal function (Alonso, n.d.), but could also be classified as a piece-wise linear function; this is a much less common family of membership functions, but it is internationally recognized as an acceptable function standard (Cingolani, 2012). The L-function begins at a fuzzy value of 0, slopes steadily upwards (linearly) beginning at a certain data value, and peaking with a fuzzy value of 1 once a specified maximum data value is reached. This function, along with a graphical illustration, can be seen in Figure 2.

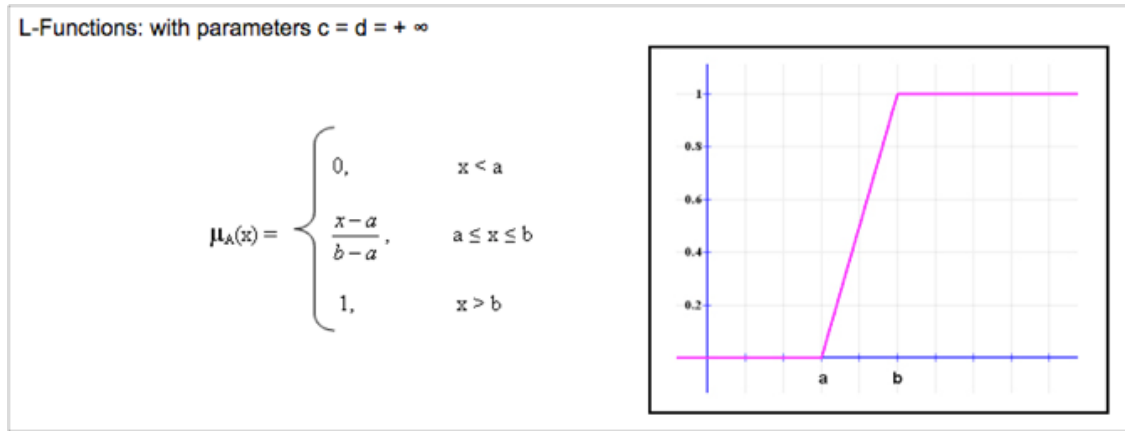


Figure 2 - Graphical Representation of L-Shaped Membership Function (Alonso, n.d.)

For this model, the beginning point of the upward slope (point a in Figure 2) is set to be the smallest data point of the data set for a particular criteria, the ending point of the slope (point b in Figure 2) is set to be the largest data point in each set, and the median point of the slope (value x in the membership equation in Figure 2) is set to equal the median of the data set for each particular criteria.

1.3. Construct the rule base

After a membership function is selected for a fuzzy set, a rule base must be constructed to control the numerical outputs. The rule base ties each fuzzy output from

the membership function to the linguistic variables described above. As mentioned previously, the rule base for this fuzzy model is simple because only two linguistic variables were necessary: 0 is the minimum fuzzy value for each criteria, and 1 is the maximum fuzzy value for each criteria, so any country with a fuzzy value of 1 for a given criteria indicates the country absolutely exposes a student to risk in that particular category (and vice versa for a fuzzy value of 0). Any fuzzy value between 0 and 1 indicates *to what degree* the particular destination exposes a student to risk in a particular area (i.e., a fuzzy value of 0.1 represents relatively minimal exposure to risk, and a value of 0.8 represents a very high degree of risk exposure but not quite absolute exposure).

2. *Fuzzification*

Once membership functions and a rule base are established, the data itself must be “fuzzified”. This essentially means each crisp data point must be converted to a fuzzy value using the membership function specified above. Once fuzzification was complete, each data point was converted to a fuzzy value in the interval $[0, 1]$.

3. *Inference & Defuzzification*

Once each data point for each destination has been converted to a fuzzy value, the results from each rule must be combined; the combination of the results of the individual rules yield a final risk result for each destination. Results of individual rules can be combined in different ways, and there are several accumulation methods that are commonly used. These accumulation methods include the maximum method, the bounded sum method, and the normalized sum method (Mendel, 1995). Because this

model seeks to assess the *total* risk for each destination, a simple accumulated sum of fuzzy values for each destination may be used (Cingolani, 2012).

To give the summed results context, one can consider the maximum and minimum possible values this sum function could return. A country that exposes its travelers to absolute risk in every risk criteria would return a fuzzy value of 1 for each criteria; thus, the maximum fuzzy risk profile for a country would be one times the number of criteria being evaluated. Similarly, a country that exposes its travelers to absolutely no risk in any criteria would return a fuzzy value of 0 for each criteria; thus, the minimum fuzzy risk profile for a country would be 0.

Once this logic was applied, it was discovered that by converting each data point to a number between 0 and 1, each risk criteria was essentially given the same weight. In a vacuum where all risk criteria are equally important to the study abroad office, this would be acceptable; however, the goal of the model is to enable the UA Office of Study Abroad & International Exchange to allocate its efforts and resources to what it considers the most important risk factors for a particular program. By converting each value to the same numerical scale without a weighting system controlled by the user, the tool provides a reduced degree of insight into how the destinations stack up based on what's most important in the minds of the stakeholders. To make the model more dynamic and more valuable to the study abroad office, building in a method to control the weight of each criteria was crucial. This proved to be a limitation of the fuzzy logic algorithm for this data set, and consequently supported the pursuit of an alternative risk model that gives the users the capability to weight criteria as they deem necessary.

Model Development – MODA Approach

MODA stands for *Multiple Objective Decision Analysis*. Traditionally, it is used to quantify the total values of multiple options for a single decision, thus serving as a tool to help decision makers choose from a collection of alternatives. For this model, the traditional MODA ideology has been applied to quantify the safety “value” a series of alternative study abroad destinations possess; in other words, while a decision analysis based on the MODA approach would quantify the value of each of the decision maker’s choices (with better options receiving higher total value scores), this modified approach will quantify the value of each destination’s safety based on the criteria being examined (with safer destinations receiving higher total value (safety) scores). The advantage of evaluating the destinations as a series of alternatives is that it allows the end user to compare multiple locations across a series of common dimensions. This value-based approach further expands this advantage by allowing the user to create strategic objectives based on the specific values each program contains (that is to say, the study abroad office can use this value-based approach to create strategies for improving student safety through targeted education programs on campus) (Hernandez, 2015).

To develop this study abroad MODA model, a template created by Dr. Gregory Parnell (Parnell, 2014) of the University of Arkansas, Fayetteville has been modified for the appropriate alternatives (the ten selected study abroad destinations mentioned previously) and objectives (maximizing/minimizing the risk criteria mentioned previously). First, each risk criteria was converted to its own value function. Every value function consists of three elements: an objective, a value measure, and a value function. To create an objective, it was determined whether a high data value for a particular risk criteria was good or bad. For example, if a large value was good (such as high urban access to clean water), the objective would be to *maximize*

urban access to clean water; similarly, if a large value was bad (such as high homicide rate), the objective would be to *minimize homicide rates*. Once a maximize/minimize objective is established for a particular risk criteria, the objective's value measure must be identified (this is the unit of the data for that criteria). For the example above, if the objective is to *minimize homicide rate*, the value measure would be the *number of deaths due to homicide per year*.

Based on the objective and value measure for a criteria, a value function must be derived; similar to the membership functions used in the fuzzy logic process, these value functions convert all data points for a particular category to fit a common scale. The value functions for this model are piecewise functions generated by the user. The inputs for each function are the data points for a particular risk criteria, so the user must first generate a scale for the x-values of the function. In a typical MODA model, this scale of x-values would begin with the minimum acceptable value (that is, the lowest value that the user would consider acceptable when considering particular alternatives). For example, in this model, the Office of Study abroad could decide that they would never consider sending a student to a destination with less than 50% access to clean water in urban areas; in this case, a value of 50% would be used as the minimum value for the x-scale. For this model, however, each scale was set to begin with 0 and end with a number equal to or greater than the largest value in that criteria's data set, to illustrate the various returns in value for the entire range of each risk criteria's values (essentially, for this model the x-values for the functions encompassed the entire scope of values in the data table). Once an x-scale has been established, the user must assign a relative value to each x-value on the scale, ranging from [0, 10]. These values represent the amount of value (i.e., safety) each input provides for the criteria; in the case of clean water access, an x-value of 100% would receive a value of 10, while an x-value of 0% would receive a value of 0. The intermediate x-values on the

scale can be assigned non-linear values between 0 and 10, thus allowing the user to represent diminishing returns of value for certain criteria as necessary. Figure 3 depicts examples of the objectives, value measures, and value functions for four different risk criteria:

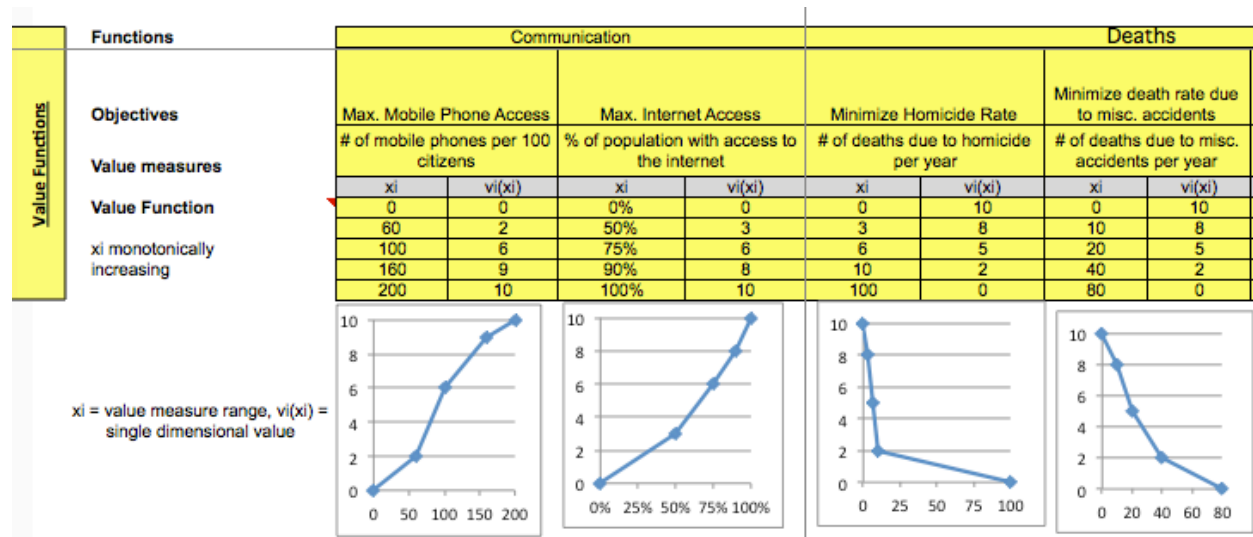


Figure 3 - Example of Risk Criteria Objectives, Value Measures, and Value Functions

Each study abroad destination is associated with a certain number for each risk criteria being evaluated; for the sake of the model's explanation, consider each of these destination/risk criteria points as individual data points (for example, the homicide rate of Shanghai, China, and the homicide rate of Rome, Italy, would each be unique data points). Using the value functions derived in the previous step, each data point must be converted to its safety value (on the previously mentioned scale of [0, 10]). These values are the *single dimensional values* of the data points. The pieces between each of the x-values of the value functions are treated as individual linear equations; each data point is located within the x-value range of the corresponding piecewise value function, and converted to its respective value.

These converted values are referred to as “single dimensional” because they have not yet been modified by user-specified swing weights. Swing weights are numbers assigned to value measures that adjust data points based on both the importance of the value measure and the variation of the scale of the value measure (Parnell, 2009). In other words, swing weights are used to adjust single dimensional values to incorporate the range of the scale and the importance of particular criteria to the user. For the development of this model, value functions were created for each risk criteria and swing weights for each criterion were assigned; to illustrate the application of the swing weight matrix in the model to a subset of the criteria, the criteria were prioritized by importance as determined by the SMEs for the swing weight matrix as follows:

- High Importance
 - Number of deaths due to homicide per year
 - Number of deaths due to miscellaneous accidents per year
 - Number of deaths due to vehicle accidents per year
 - Number of doctors per capita
- Medium Importance
 - Number of mobile phones per capita
 - Percentage of urban population with access to clean water
- Low Importance
 - Percentage of population with access to the internet
 - Percentage of rural population with access to clean water

After determining the importance of each criteria, the range of values for each criteria was calculated by subtracting the smallest single dimensional value for each criteria from the largest single dimensional value for the corresponding criteria. The single dimensional values represented the public domain data after being transformed by the value functions, so each of these calculations resulted in a criteria range between (0, 10). The criteria were placed in the swing weight matrix in descending order of ranges for each level of importance. The result was the following swing weight matrix depicted in Table 2:

Table 2 - Swing Weight Matrix Used for Development of Model

Highest Weight		Level of importance of the value measure								
		Value Measure	Swt	Mwt	Value Measure	Swt	Mwt	Value Measure	Swt	Mwt
Range of Variation of the Value Measure	Large	# of deaths due to homicide per year	100	0.190						
		# of deaths due to vehicle accidents per	95	0.181	# of mobile phones per 100 citizens	70	0.133	% of population with access to the	30	0.057
		# of doctors per capita (i.e. per 1000 citizens)	90	0.171						
	Medium									
		# of deaths due to misc. accidents per year	80	0.152						
	Small									
					% of urban population with access to clean	50	0.095	% of rural population with access to clean	10	0.019

One important feature of the swing weight matrix is that it must reflect consistency between each of the individual swing weights. While it is intuitive that a very important criteria with a large range of variation should be given a higher weight than a criteria with low importance and a small range of variation, it is much harder to assess the trade-off between criteria whose characteristics are more similar (such as a high importance/medium range criteria as compared to a medium importance/large range criteria). To account for this, weights should descend in magnitude as one moves diagonally across the matrix, from the top-left to the bottom-right (Parnell, 2009). This was taken into account as the swing weights in the figure above were derived. All of the swing weights (represented as *Swt* in Table 2) for all of the criteria were then

summed together, and each criteria was given a weight measure as a proportion of its swing weight to the total sum of swing weights (represented as Mwt in Table 2). The result is a normalized swing weight for each criteria, with the sum of all normalized swing weights totaling to a value of one. Each criteria's normalized swing weight is then multiplied by all of that criteria's single dimensional values, thus assigning user-specified weights to each value.

After all of a country's weighted values are computed, they are summed together to produce a composite safety measure (since all value functions were assigned the maximum value of 10 for the safest value in each range, the weighted values and the cumulative totals represent each country's safety level, *not* each country's risk level). Since the value measures derived earlier in the process are all on the scale between [0, 10], each country's total safety level (once weights are applied to each measure) will also be displayed on a scale between [0, 10], with the optimal composite safety measure equaling 10.

Validity Testing

The MODA approach is more robust and customizable because it enables the user to alter the importance of various factors as new educational programs are implemented and priorities shift. Because of this, the decision was made to provide the UA Office of Study Abroad & International Exchange with the MODA data model over the fuzzy logic model (this decision was also highly recommended by Dr. Edward A. Pohl, one of the University of Arkansas's leading experts in data modeling). Once the decision to move forward with MODA was made, the next step was to test the validity of the model with the end users themselves.

To test the model's validity, the *face validity* approach was applied with key stakeholders and end users for the model. *Face validity* is a recognized method of validity testing conducted

by a project's stakeholders that confirms a measure or process appears to assess the construct being evaluated as intended, by letting the stakeholders themselves interact with the measure or process to determine whether or not it operates as intended (Phelan & Wren, 2006). Two key stakeholders participated in validating the model developed for this research: DeDe Long, the Director of Study Abroad and International Exchange at the University of Arkansas, and Sarah Malloy, the Assistant Director of Faculty-Led Programs and Risk Management for the University of Arkansas Office of Study Abroad and International Exchange. Together, these two experts have over 30 years of experience in study abroad and international exchange.

After an explanation of the MODA approach, the swing weight matrix mentioned previously was shown to the end users, who confirmed that the ranges of values and the rankings of importance aligned with their intuition and experiences. They also confirmed the value functions, giving credibility to the calculations that were implemented within the model. The public domain data that had been collected was evaluated next, and the users were asked whether or not the results aligned with their expectations. They analyzed the resulting outputs and confirmed that the model made sense as it quantified the countries' safety factors in a logical and reasonable way. As subject matter experts in the field of international travel and study abroad, the end users from the study abroad office are qualified to make these assessments; for example, one expectation was that Mexico City, Mexico should be significantly riskier than any other destination being evaluated, while places like Rome, Italy, and Sydney, Australia, should both be relatively safe when compared to the baseline of Fayetteville, Arkansas. When all of the data was taken into account, these assumptions were confirmed by the final outputs of the model (Mexico City, Mexico was shown to be nearly three times riskier than Fayetteville, Arkansas, while Rome, Italy, and Sydney, Australia were both shown to be marginally safer than the baseline).

These factors allowed the study abroad experts to confirm that the algorithm behind the model was accurate, and that it could reasonably help guide future decision making.

To further test the model's utility as a scalable future tool, the end users were also provided an incomplete version of the study abroad MODA model, including eight of the specified destinations and eight of the specified risk criteria. A step-by-step user manual was also provided, with instructions for both how to add a new destination to the model and how to add a new risk criteria to the model (these instructions can be seen in Appendix A, [Error! Reference source not found.](#) and [Error! Reference source not found.](#)Table A - 2). The users were given an explanation of how MODA works and what the graphs in the file represent, and were then given an opportunity to independently walk through the steps of the user manual to build comfort with expanding the model. The end users confirmed that the user manual was thorough and complete, which means the tool could in fact be easily built up in the future to incorporate more criteria and destinations.

Results & Conclusions

The primary contribution of this research was building a model to assist the UA study abroad office in its evaluation of various destinations, not the specific results the model generated. Still, the model's usefulness can be demonstrated by making general conclusions (drawn in a similar fashion to the conclusions the end users might reach when using the model for its intended application) given the inputs used to build and validate the initial tool. Assuming the swing weights are assigned as seen in Table 2 (shown previously), Figure 4 shown below depicts the total safety value outputs would be achieved based on the current risk data in the model:

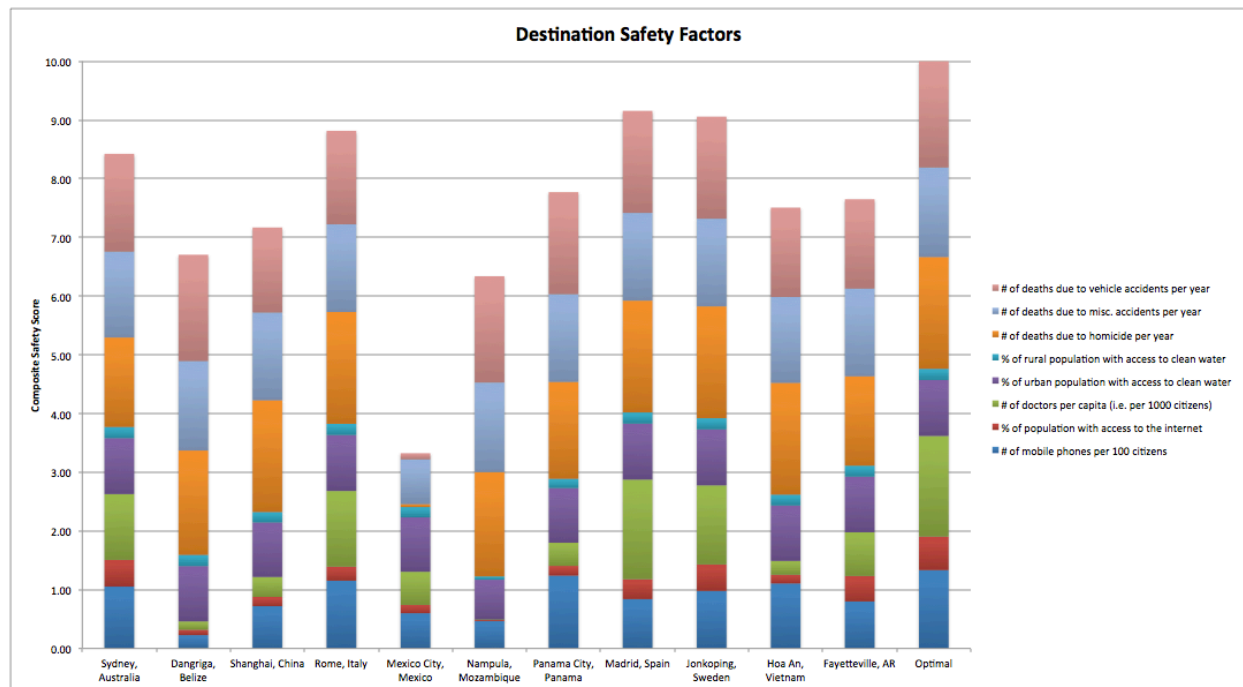


Figure 4 - Destination Safety Factors Based on Initial Value Functions & Swing Weight Matrix

As illustrated above, it can be asserted that Mexico City, Mexico (at a value of 3.32) is 2.3 times more dangerous than the Fayetteville, Arkansas baseline (at a value of 7.65). Using these swing weights, five destinations (Sydney, Australia; Rome, Italy; Panama City, Panama; Madrid, Spain; and Jonkoping, Sweden) are actually safer than the baseline Fayetteville, Arkansas, as their values exceed 7.65. The highest-rated destination in terms of total safety (Madrid, Spain) is given a composite safety score of 9.15 out of 10.00, while the lowest-rated destination (Mexico City, Mexico) is given a safety score of only 3.32 out of 10 (this low score is mostly due to Mexico's high homicide and vehicle death rates, which are both given a high priority in the swing weight matrix).

These results contribute to the validity of the model, as they generally align with what the study abroad experts anticipated when selecting these specific programs. As mentioned

previously, four destinations (Vietnam, Sweden, Panama, and Australia) were selected because they have a generally safe perception; based on the previously determined swing weight matrix, Sweden, Panama, and Australia did in fact score higher in total safety than the Fayetteville, Arkansas baseline, while Vietnam scored only slightly lower, supporting this generally safe perception. On the other hand, three destinations (Mexico, Shanghai, and Mozambique) were selected for their generally risky perception. Based on the results generated by the current model, all three locations did in fact score lower than the baseline, again validating that the model works as the end users expected.

While these conclusions hold true given the previously mentioned swing weight matrix, it is important to consider how these results might change if a different matrix of values was used instead. To test the sensitivity of these results, the model was tested a second time with the following swing weight matrix depicted in Table 3:

Table 3 - Modified Swing Weight Matrix for Sensitivity Analysis

Highest Weight		Level of importance of the value measure								
		Value Measure	Swt	Mwt	Value Measure	Swt	Mwt	Value Measure	Swt	Mwt
Range of Variation of the Value Measure	Large							# of deaths due to homicide per year	35	0.082
		# of mobile phones per 100 citizens	100	0.235	% of population with access to the	55	0.129	# of deaths due to vehicle accidents per	30	0.071
								# of doctors per capita (i.e. per 1000 citizens)	25	0.059
	Medium									
								# of deaths due to misc. accidents per year	10	0.024
	Small									
		% of urban population with access to clean	90	0.212						
		% of rural population with access to clean	80	0.188						

Since the range of variation for the risk criteria's didn't change, the value measures were simply rearranged with different levels of importance (for example, death rates and doctor presence were assigned a low level of importance in the new swing weight matrix, while Internet access and clean water access were given high levels of importance). Evaluating the same data set with this new swing weight matrix generates the following results as depicted in Figure 5:

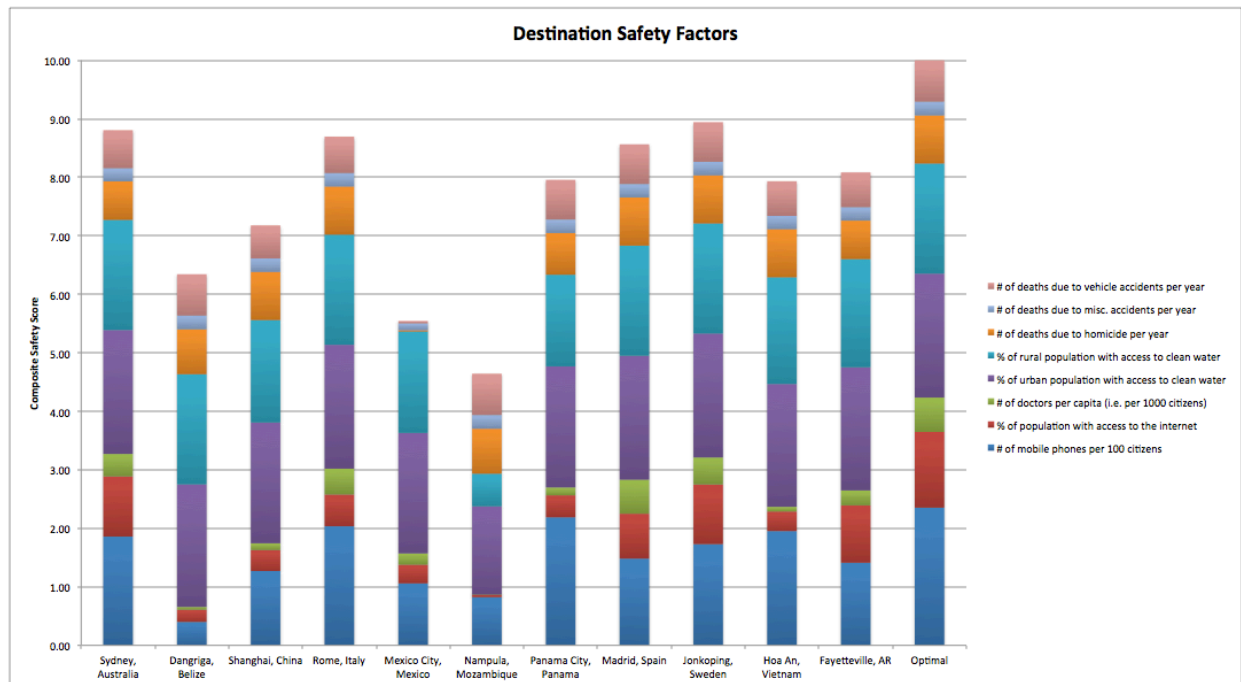


Figure 5 - Destination Safety Factors Resulting from Modified Swing Weight Matrix

As seen in Figure 5, the order and weight given to the risk criteria can have a considerable impact on the final output of the model. For example, with the new swing weight matrix (from Table 3), the model assigns a much higher value to Mexico City, Mexico (5.54); this is because Mexico City's worst risk criteria (death rates) were given a relatively low level of importance (and therefore a relatively low swing weight) while criteria for which Mexico City rated relatively highly in (such as clean water access) were given high levels of importance (and therefore relatively high swing weights). Because of this, Mexico City's safety value appears to be quite high compared to the previously generated safety value, since its worst scores were given the least weight. In fact, under this new swing weight matrix, many of the destinations were given a higher total safety ratings because most of the destinations evaluated in this version of the model had relatively high access rates to clean water. The sensitivity of the total safety factors reflects why it is important for the expert end user to select appropriate swing weights for

each criteria, but it also shows how powerful the tool can be in evaluating destination risk as the UA study abroad office's priorities change and various risk criteria are addressed.

Contributions and Future Work

Through the completion of this research, I have made several contributions that will add to the body of knowledge and benefit the University of Arkansas, and especially its Office of Study Abroad. First, by building this model with help from study abroad experts, I have created a working, validated study abroad risk analysis tool that previously did not exist. Along with this model, I have also created a step-by-step user manual for expanding the model. Future users of the model can reference this instruction manual to build the model even further, by enabling them to add additional destinations and risk criteria. Finally, by building this model with the end user in mind, I have given the University of Arkansas Office of Study Abroad a way to quantify the risks of various destinations, which can help them both evaluate new program opportunities and develop strategic risk mitigation training for existing programs.

As stated earlier, this model focused on ten different cities to give the model a wide scope of programs to evaluate, covering both ends of the risk spectrum. Now that the framework has been set, this model could be expanded in a future endeavor to include more study abroad destinations. While the ten programs used for this particular research project were selected in an attempt to make the model more robust in terms of its ability to quantify the risk between specific groups of destinations, adding additional destinations into the framework of the model would further contribute to the depth of its effectiveness. Further, if more specific data could be obtained, the model could be replicated, with another version focusing on the unique risks associated with international internships while the original model continues to focus on study abroad data. Similarly, the model could also be replicated for individual destinations of interest.

In-country statistics could be analyzed as a data subset within the model if the user had interest in digging further down into the safety of a particular location.

Within the original model, there is also future opportunity to expand its focus on countries in which the University of Arkansas offers year-long programs. When studying for long periods of time in non-English speaking countries, students often have to learn the language of their host countries while they are abroad. Studies have shown that students who study abroad get the highest yield in terms of language gain when they stay abroad for a full year (Desruisseaux, 1999), so utilizing this model to increase safety awareness for year-long programs could make them more attractive options for University of Arkansas students, which would benefit students who are trying to learn a language while they are abroad. To facilitate this expansion of the model, more specific statistics would need to be collected that address year-long study abroad risks.

If a metric were available to quantify the risk associated with a particular location due to political instability or social unrest, this model could be further improved to account for more “random” acts of crime. While random violence can theoretically occur anywhere at any time, there is a perception that these crimes are more likely to occur in certain countries which are perceived to be riskier than others. For example, in 1999, a US student traveled to Israel and rode a particular bus that was subject to an attempted bombing the very next day (Begun, 2001); Israel could be perceived as inherently more dangerous than a traditional European destination, for example, based on its social and political turmoil, but without a way to quantify that additional risk, it is hard for the University of Arkansas’s study abroad office to see quantitatively that Israel (or any other country in a similar situation) needs to be targeted with more specific educational training before students and faculty go there for a study abroad session.

Implementing this type of metric would help the study abroad office identify for which programs it should focus on developing social awareness programs.

While future expansion of this model is recommended to include social factors like those previously mentioned if possible, it is also recommended that future users incorporate qualitative analysis with the model's outputs before making decisions. The MODA model developed in this study is highly data driven, resulting in a very mathematical approach to assigning risk. The benefit of this approach is that it is driven by public domain data, but as a result it excludes risk factors that are either hard to quantify, or hard to compile data for. Qualitative analysis (for categories such as terrorist activity, for example) would give the numerical outputs of the model more context, allowing the end user to incorporate additional considerations that aren't immediately quantifiable into their analysis and decision making. In cases where the user wants to mathematically incorporate qualitative factors, but the factors can't be explicitly quantified, the user could add additional risk criteria to the model with constructed quantitative scales, generating destination data from field experts for each criteria through surveys or other data collection processes. The collected responses could be aggregated (such as the average of all responses for a particular risk criteria) and converted like any other quantitative data point according to the value function associated with a constructed scale (for example, if the qualitative risk criteria is "Likelihood of a Civil War Outbreak," experts could be polled to determine how likely they believe this event is to occur for a particular destination on a scale of 1-10, while the user builds a constructed value scale to assign value these "quantitative" responses).

As confirmed by study abroad experts at the University of Arkansas, this model is a powerful tool that can provide a strong foundation for educated decision making, but due to the

limitations mentioned above, it should not be considered a complete solution without future expansion. The model's accuracy and increased reliability will depend on the end users applying their expertise to update criteria swing weights appropriately and implement additional risk factors that aren't currently accounted for. Even in its current limited state, this model can still drive decision making by quantifying and graphically representing how safe various destinations are, and which risk categories could be improved for each destination.

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Appendix A – MODA Workbook Update Instructions

The following tables outline the step-by-step process a user should follow to update the “Study Abroad MODA Model” file. Table A-1 outlines the process for adding a new destination to the file, and Table A-2 outlines the process for adding new risk criteria to the model.

Table A - 1: MODA Model Instructions (adding a destination)

1.	Open "Data" worksheet
2.	Select purple column by clicking letter at top of column (Figure A - 1)
3.	Insert a new column
4.	In row 2 of the new blank column, type the name of the destination being added
5.	Beginning in row 3 of the new blank column, use the links at the far right of the data table to manually insert data values for the new country
6.	Open "Value Model" worksheet
7.	Select the bottom-most row (Fayetteville, AR row) in "Country Attributes" panel (click number to left of row) (Figure A - 2)
8.	With the Fayetteville, AR row selected, insert a new row
9.	In the new blank cell in column B, type the name of the new destination as it appears in the "Data" worksheet
10.	For each risk criterion (column C&D, column E&F, etc.), copy the formula in each cell above the new blank row down into the empty yellow cells in the new row
11.	Select the bottom-most row (Fayetteville, AR row) in the "Unnormalized Values" panel (click number to left of row) (Figure A - 3)
12.	With the Fayetteville, AR row selected, insert a new row
13.	Copy the formula in the cell above the new blue cell (column B) down into the new blank blue cell
14.	For each risk criterion (column C&D, column E&F, etc.), copy the formula in each cell above the new blank row down into the empty green cells in the new row
15.	Select the 2 nd -bottom-most row (Fayetteville, AR row) in the "Weighted Values" panel (click number to left of row) (Figure A - 4)
16.	With the Fayetteville, AR row selected, insert a new row
17.	Copy the formula in the cell above the new blue cell (column B) down into the new blank blue cell
18.	For each risk criterion (column C&D, column E&F, etc.), copy the formula in each cell above the new blank row down into the empty green cells in the new row
19.	The new destination should now appear in the "Destination Safety Factors" bar chart at the bottom of the worksheet

	A	B	C	D	E	L	M	N	O	P	Q	R
1												
2				Sydney, Australia	Dangriga, Belize	Jonkoping, Sweden	Hoa An, Vietnam		Fayetteville, AR	Link		
3		Communi	Mobile/100	138	51	127	146		100	https://www.cia.gov/library/publications/the-v		
4			Internet %	89.6%	26.8%	0.891	0.43		86.8%	https://www.cia.gov/library/publications/the-v		
5		Health	Physician De	3.27	0.83	3.93	1.19		2.45	https://www.cia.gov/library/publications/the-v		
6			Urban Water	100.0%	98.9%	1	0.991		99.4%	https://www.cia.gov/library/publications/the-v		
7			Rural Water	100.0%	100.0%	1	0.969		98.2%	https://www.cia.gov/library/publications/the-v		
8		Deaths	Homicide	0	1	0	0		3	http://travel.state.gov/content/travel/en/statis		
9			Misc. Accider	2	0	1	2		1	http://www.city-data.com/crime/crime-Fayett		
10			Vehicle Accid	2	0	1	4		4	http://static.ark.org/eeuploads/asp/AR_FY12		

Figure A - 1: Purple Column in "Data" Worksheet

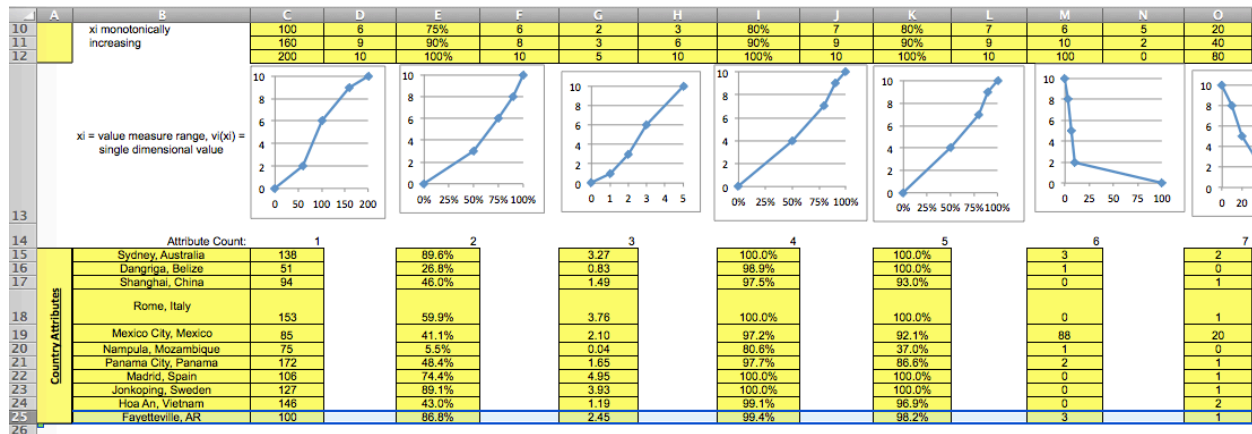


Figure A - 2: Fayetteville, AR Row Selection: Country Attributes Section, "Value Model" Worksheet

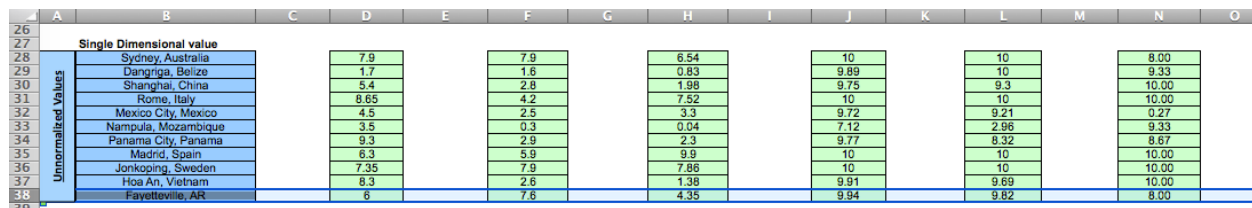


Figure A - 3: Fayetteville, AR Row Selection: Unnormalized Values Section, "Value Model" Worksheet

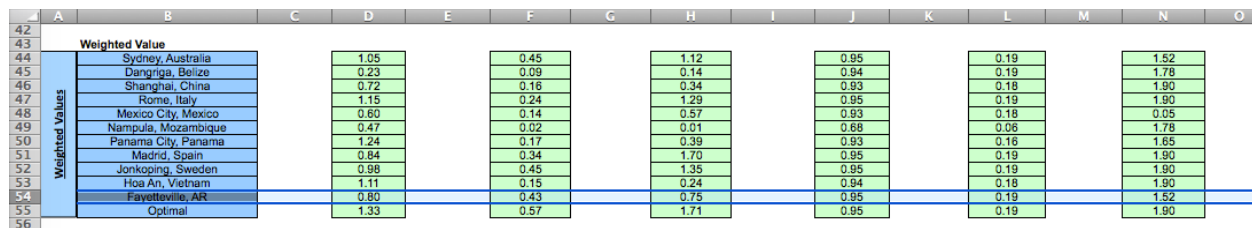


Figure A - 4: Fayetteville, AR Row Selection: Weighted Values Section, "Value Model" Worksheet

Table A - 2: MODA Model Instructions (adding a risk criteria)

1.	Open "Data" worksheet
2.	In the first blank row at the bottom of the existing data set, type a name for the new criteria in the cell in column C
3.	Add values in this row for the new criteria for each destination identified at the top of each column (beginning with column D and moving right)
4.	In the blank cell to the right of the right-most data entry for the new criteria, add a link to the page where data for the new criteria can be obtained
5.	Open "Value Model" worksheet
6.	Select the two columns immediately to the right of the last "value function" block (found in rows 4-13) (Figure A - 5)
7.	Insert columns (two new columns with partial color formatting should appear)
8.	Copy the formats of the two columns to the left of the two newly inserted columns, and paste it over the two new columns (this should replicate all cell fills, number formatting, and cell outlines for the new columns)
9.	Select the cell in row 5 of the newly inserted columns (the two row 5 cells of the new columns should be merged into one cell; if not, formats did not copy over properly)
10.	For the new criteria being added, determine whether a higher value or lower value is safer (for example, high access to clean water or low homicide rate)
11.	In the row 5 cell, type an objective function for the new criteria, using existing objectives as a template (if a high value for the new criteria is good, the objective will be to <i>maximize</i> ; if a low value is good, the objective will be to <i>minimize</i>)
12.	Select the cell in row 6 of the new columns (directly below the objective typed in the previous step)
13.	In this cell, type out what is being measured for the new criteria, using existing value measures as templates
14.	Copy the values in row 7 of the two columns to the left of the new columns, and paste them in the row 7 cells of the two new columns
15.	In rows 8-12 under the left (xi) new column, create a scale of numbers beginning with 0 and ending in a number <i>equal to or greater than</i> the largest value of the new criteria in the "Data" worksheet
16.	In rows 8-12 under the right (vi(xi)) new column, if the objective is to <i>minimize</i> the new criteria, type "10" next to the 0 cell in the left column and "0" next to the greatest value in the left column
17.	In rows 8-12 under the right (vi(xi)) new column, if the objective is to <i>maximize</i> the new criteria, type "10" next to the greatest value in the left column and "0" next to the 0 cell in the left column
18.	For the remaining three cells (rows 9-11), fill in integers greater than 0 and less than 10, creating a value scale (each integer should represent the value of the criteria to its left, with 10 representing maximum value and 0 representing no value)
19.	Copy the graph to the left of the new columns, and paste it on cell 13 of the new columns
20.	Select a data point in the newly pasted graph, thus selecting all of the data points on the graph
21.	Right click the data point and choose "select data"
22.	In the dialog box that pops up, the chart data range should already be selected (highlighted in blue). With this range selected, click cell 8 of the left new column and drag right and down through cell 12 of the right new column
23.	The data points should automatically update on the new graph. Right-click the x-axis of the new graph, choose "format axis", select "scale", and change the values in the dialog box as desired to re-fit the scale to the new data set (if desired)
24.	In cell 14 of the left new column, type an integer <i>one greater than</i> the integer to the left of the new columns (see the pattern across row 14)
25.	Copy the cells in the yellow boxes (beginning in row 15) of the criteria to the left of the new criteria, and paste them into the blank yellow boxes (beginning in row 15) in the new columns (each cell should return #N/A)
26.	In the row 15 cell of the left new column, select the first argument of the function in the cell and type "B15"

27.	In the row 15 cell of the left new column, select the second argument of the function in the cell (select everything between the first and second commas, it should begin with "Data!")
28.	With the second argument selected, open the "Data" worksheet. Select the entire data range, beginning with in cell D2, continuing right through the "Fayetteville, AR" cell and down through the new row being added to the data set
29.	Return to the "Value Model" worksheet. The top yellow cell should now return the data value for the first country for the new criteria being introduced. Copy this cell and paste it over the "#N/A" values in the remaining yellow cells in the column
30.	Copy the first cell at the top of the first block of green cells for the criteria to the left of the new columns, and paste it into the blank green box in the first block of green cells in the right new column
31.	In the newly pasted cell, select the second argument of the function (everything between the first and second commas). With this highlighted, select cells 8-12 of the left new column. Lock the range (F4 for Windows, command+T for Mac) and press enter
32.	In the newly pasted cell, select the third argument of the function (everything to the right of the second comma). With this highlighted, select cells 8-12 of the right new column. Lock the range (F4 for Windows, command+T for Mac) press enter
33.	Copy this function and paste it into the remaining empty green cells (only the first block of green cells) in the right new column
34.	Copy the function in the blue cell to the left of the new columns, and paste it in the empty blue cell under the green block of cells referenced in the previous step
35.	Copy the text in cell 6 of the new column (i.e. the new criteria's value measure)
36.	Open the "Swing Weight Matrix" worksheet. In column S, right click and select "paste special". Choose "Values" and "Transpose", then select "OK" to paste the text underneath the existing list of value measures in the next available blank cell (Figure A - 6)
37.	Once the new value measure is added to the list, the cell to its right should say "Missing". This indicates that the new value measure hasn't been added to the swing weight matrix yet. To update the swing weight matrix:
	a. The swing weight matrix is laid out in order of importance, with the most important criteria (according to the user) in the left of the matrix, and less important criteria (according to the user) in the right of the matrix
	b. Every swing weight (denoted "swt" in the matrix) must be <i>greater than</i> the swing weights <i>directly below and directly to the right of it</i> (Table 2)
	c. To add a new value measure, determine which criteria it is more important than, and which criteria it is less important than. That will help you determine where in the matrix it belongs
	d. Once the user decides how (relatively) important the new value measure is, select the appropriate blue cell in the matrix. Type an equal sign "=" and click the value measure you just pasted at the bottom of column S. Press enter.
	e. Next, select the blank yellow cell to the immediate right of the blue cell you just edited. In this cell, type a numerical value to assign the new criteria an appropriate weight (note that it must be a number greater than the value immediately below/to the right of the cell)
	f. After assigning the new criteria a swing weight, press enter. The green cell to the right of the newly-filled in yellow and blue cells should automatically update with a weighted value. In column S, the "Missing" text should now disappear for the new criteria
38.	Open the "Value Model" worksheet
39.	Copy the green cell to the left of the blank green cell in the right new column (under the blue cell to the left of the new columns), and paste it into the blank green cell under the blue cell of the right new column
40.	The green cells immediately to the right of the newly added green and blue cells should now read "Error in Weights". To fix this, select the second half of the first argument in the sum function (after the ":") and click the cell immediately to the left of each of these green cells
41.	Copy the first cell at the top of the second block of green cells for the criteria to the left of the new columns, and paste it into the blank green box in the second block of green cells in the right new column
42.	With the newly pasted cell selected, select the first argument of the function (everything between

	the equal sign and the asterisk)
43.	With this argument selected, click the green cell immediately above the active cell in the new right column. Lock this cell reference (F4 for Windows, command+T for Mac) and press enter
44.	Copy this cell, and paste it into the remaining blank green cells in the right new column
45.	The bottom cell in this second block of green cells should contain a value of 0. To fix this, select the second argument in the cell's function (everything to the right of the asterisk) and type the number "10". Press enter
46.	Select the top green cell under the yellow "Total Value" cell to the right of the second block of green cells in the right new column.
47.	With this cell selected, select the second half of the argument in the cell's function (everything to the right of the ":"). Once that argument is highlighted, click the green cell immediately to the left of the active cell (the top cell in the second block of green cells in the right new column)
48.	After entering this change, copy the function down into the rest of the green cells below the previously edited cell
49.	Click the "Destination Safety Factors" bar chart at the bottom of the worksheet to select it. With the chart selected, right click in the white space of the chart and click "Select Data". A dialog box should appear
50.	Under the data series in the dialog box, click "Add". Click into the box next to the "Name" range, then click the row 6 cell in the newly inserted columns (the cell that contains the new criteria's value measure)
51.	Click into the box next to the "Y Values" range and delete the default text. Select the second block of green cells at the bottom of the right new column.
52.	Press "OK" at the bottom of the dialog box. The graph should update, adding a new block to the top of each existing destination's value bar to represent its value for the new criteria (the "Optimal" destination's value should add up to "10")

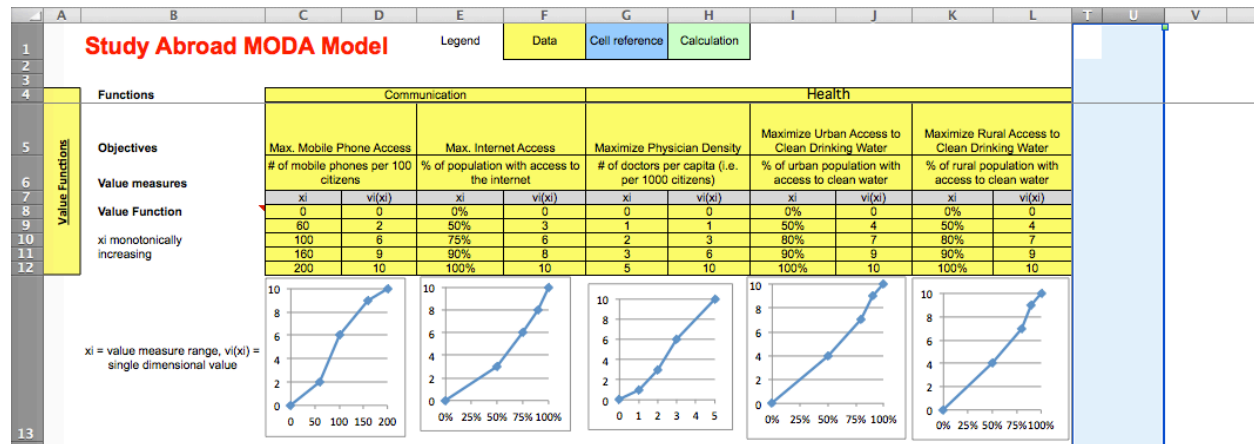


Figure A - 5: Selection of Blank Columns to Right of "Value Functions" Section

	G	H	I	J	K	L	M	N	R	S	T
1											
2	Level of importance of the value measure									Value Measure	Missing from Matrix?
3	Value Measure	Swt	Mwt	Value Measure	Swt	Mwt					
4										# of mobile phones per 100 citizens	
5	# of mobile phones per 100 citizens	70	0.133	% of population with access to the	30	0.057				% of population with access to the internet	
6										# of doctors per capita (i.e. per 1000 citizens)	
7										% of urban population with access to clean water	
8										% of rural population with access to clean water	
9										# of deaths due to homicide per year	
10										# of deaths due to misc. accidents per year	
11	% of urban population with access to clean	50	0.095	% of rural population with access to clean	10	0.019				# of deaths due to vehicle accidents per year	
12											

Figure A - 6: List of Value Measures for Swing Weight Matrix